PREFERENCE FOR A STIMULUS THAT FOLLOWS A RELATIVELY AVERSIVE EVENT: CONTRAST OR DELAY REDUCTION?

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Several types of contrast effects have been identified including incentive contrast, anticipatory contrast, and behavioral contrast. Clement, Feltus, Kaiser, and Zentall (2000) proposed a type of contrast that appears to be different from these others and called it within-trial contrast. In this form of contrast the relative value of a reinforcer depends on the events that occur immediately prior to the reinforcer. Reinforcers that follow relatively aversive events are preferred over those that follow less aversive events. In many cases the delay reduction hypothesis proposed by Fantino (1969) also can account for such effects. The current experiments provide a direct test of the delay reduction and contrast hypotheses by manipulating the schedule of reinforcement while holding trial duration constant. In Experiment 1, preference for fixed-interval (FI) versus differential-reinforcement-of-other-behavior (DRO) schedules of reinforcement was assessed. Some pigeons preferred one schedule over the other while others demonstrated a position (side) preference. Thus, no systematic preference was found. In Experiment 2, a simultaneous color discrimination followed the FI or DRO schedule, and following training, preference was assessed by presenting the two positive stimuli simultaneously. Consistent with the contrast hypothesis, pigeons showed a significant preference for the positive stimulus that in training had followed their *less* preferred schedule.

Key words: within-trial contrast, contrast, stimulus preference, delay reduction, cognitive dissonance, key peck, pigeons

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Contrast refers to a comparison between two conditions in which the difference between them is amplified by the presence of the other. Three forms of contrast have been identified in the literature: incentive contrast, anticipatory contrast, and behavioral contrast.

Incentive contrast occurs when there is a sudden, unexpected increase or decrease in reinforcement resulting in an overreaction to the change relative to a control group that experienced the final magnitude of reinforcement from the start. For example, Crespi (1942) trained rats to run for a large food reinforcer and then shifted them to a smaller reinforcer. Another group of rats was trained to run for a small food reinforcer and was then shifted to a larger amount of food. Running speed was compared to rats that had not experienced a shift in reinforcer magnitude. Rats that were shifted to smaller reinforcers ran slower than rats that had been trained to run for small reinforcers from the start

(negative incentive contrast), and rats that were shifted to larger reinforcers ran faster than rats that had been trained with large reinforcers from the start (positive incentive contrast).

A second form of contrast, anticipatory contrast, is observed when there are repeated predictable changes in reinforcer magnitude. Anticipatory contrast is assessed in anticipation of the change in reinforcement, and the dependent measure is typically a consummatory response rather than running speed. For example, Flaherty (1982) found that rats would drink less of a weak saccharin solution if they had learned that it would be followed by a strong sucrose solution relative to a group that had learned that it would be followed by another weak saccharin solution.

The third form of contrast, behavioral contrast, usually is observed during discrimination training with free-operant procedures (Reynolds, 1961) but can be found with discrete-trial procedures as well (Bower, 1961). For example, subjects are trained on an operant task involving a multiple schedule of reinforcement. Contrast is demonstrated when a change in the rate of reinforcement in one schedule is followed by a change in responding (in the opposite direction) in the unchanged schedule. Although the mechan-

isms responsible for behavioral contrast are not entirely understood (see Williams, 2002), there is evidence that it results primarily from the anticipation of a worsening schedule of reinforcement (anticipatory contrast) and only marginally and transiently from the shift from a leaner schedule to a richer schedule (local contrast).

Clement, Feltus, Kaiser, and Zentall (2000) proposed a fourth type of contrast that could not easily be subsumed under any of the existing types because although it was a reaction to a prior event, unlike local contrast it develops slowly and does not appear to dissipate with training. Clement et al. called this effect within-trial contrast because it appeared to result from the contrast of events within a discrete trial. In their study they asked whether a high response requirement would affect the value of the reinforcer that followed differently from a low response requirement. They examined the preference for discriminative stimuli that followed either a low ratio pecking requirement or a high ratio pecking requirement. On low ratio trials (FR 1), a single peck to a circle on the center key was followed by a simultaneous hue discrimination ($S+_1$ $S-_1$). Food reinforcement followed choice of the S+. On high ratio trials (FR 20), the pigeons were required to peck at the same circle 20 times before being presented with a different simultaneous discrimination ($S+_{20}$ $S-_{20}$). Following training, the pigeons were tested with two novel combinations of stimuli: either both previously positive stimuli ($S+_1$ $S+_{20}$) or both previously negative stimuli ($S-_1$ $S-_{20}$). Choice was nondifferentially reinforced (50%).

According to traditional theories of learning (e.g., Hull, 1943; Spence, 1937), the pigeons should not have shown a stimulus preference because in the presence of both S+ stimuli, equal effort was required to produce equal reinforcement at an equal delay. Alternatively, the pigeons could have developed a backward association between the hues and the preceding response (Spetch, Wilkie, & Pinel, 1981). That is, the pigeons could have preferred the stimuli that followed less effort because those stimuli were associated with less effort in the backward direction. Along similar lines, the context in which a single peck was sufficient to produce the S+ could be viewed as more reinforcing than the context in which 20
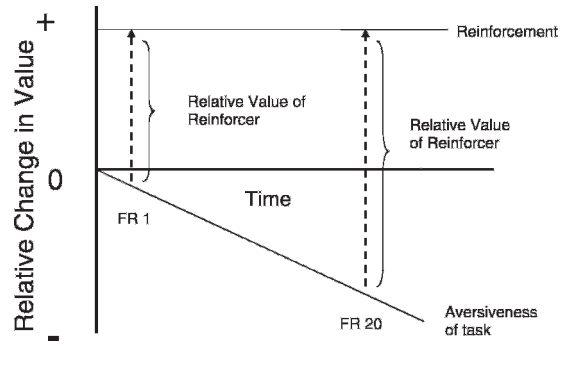

Fig. 1. Model of within-trial contrast based on relative hedonic states. Each trial begins at a relative value of 0. Key pecking (or another nonpreferred event such as delay) causes a negative change in value, and reinforcement results in a positive change in value. The FR 20 response requirement results in a relatively more negative change in value than does the FR 1 requirement and hence in a greater positive change in value upon obtaining the reinforcer. Adapted from Zentall (2005).

pecks were required to produce the S+. According to either the backward-association or more-reinforcing-context view, on test trials pigeons should have preferred the positive hue that in training had followed the low-ratio response over the positive hue that followed the high-ratio response.

Contrary to both of these predictions, Clement et al. (2000) found that pigeons preferred the S+ stimulus that in training followed the higher ratio of responding over those that followed the lower ratio of responding. Clement et al. hypothesized that a within-trial contrast effect could have produced the stimulus preference found. According to this account, the value of the positive stimuli (as a signal for food) should depend on the relative aversive event administered immediately prior to presentation of each discrimination. High ratio trials are assumed to be more aversive than low ratio trials. Thus, greater contrast should occur upon the appearance of the discriminative stimuli on high ratio trials than on low ratio trials (see Figure 1). This hypothesis predicts that when the discriminative stimuli appear, the larger the change from aversive to appetitive event, the greater the preference should be for the stimuli that follow (Zentall, 2005).

The contrast hypothesis is based on the assumption that any relatively aversive event that precedes the discriminative stimuli will result in a preference for those stimuli over

stimuli that follow a less aversive event. For example, contrast should occur when discriminative stimuli follow a longer rather than a shorter delay and also when the prior event is the absence rather than the presence of food or even a mild shock rather than the absence of shock. These predictions are important because they are counterintuitive. They predict that something relatively aversive will produce a preference for the stimuli that follow.

DiGian, Friedrich, and Zentall (2004) tested the first prediction involving delays. DiGian et al. used differential initial stimuli to signal a 6-s delay (e.g., vertical lines) on some trials and no delay (e.g., horizontal lines) on others. One pair of discriminative stimuli was presented after the delay and a different pair of discriminative stimuli was presented after no delay, with choice of the S+ in each pair reinforced. On test trials, the pigeons were given a choice between the two positive stimuli (S+$_{delay}$ S+$_{no\ delay}$) and consistent with the contrast account, the pigeons preferred the S+ that followed a delay in training over the S+ that did not follow a delay.

Friedrich, Clement, and Zentall (2005) tested the second prediction involving food versus the absence of food as the prior event. On half of the training trials they presented pigeons with a stimulus (e.g., horizontal lines) that predicted the occurrence of food followed by one pair of discriminative stimuli (e.g., red+ and yellow−), and pecking the S+ then led to food reinforcement. On the remaining trials, a different initial stimulus (e.g., vertical lines) predicted the absence of food followed by a different pair of discriminative stimuli (e.g., green+ and blue−), and pecking the S+ then led to food reinforcement. On test trials, when the pigeons were given a choice between the two positive discriminative stimuli (e.g., red and green), they reliably preferred the S+ that had followed the absence of food over the S+ that had followed the presence of food. Thus, once again, a relatively aversive event (in this case the absence of food) appears to have produced a preference for the stimuli that follow.

Although the contrast interpretation is supported by several findings, an alternative account can be proposed. Fantino (1969) suggested that presentation of any stimulus that is associated with a reduction in the delay
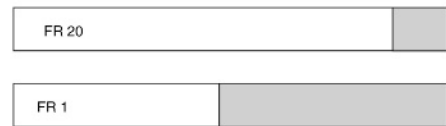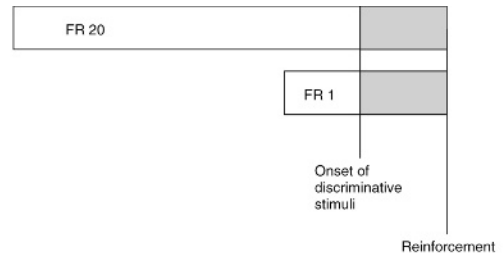

Fig. 2. Absolute (top) and relative (bottom) delay reduction as applied to the procedure used by Clement et al. (2000). The absolute time between the presentation of the discriminative stimuli and food reinforcement (top) is the same on FR 20 and FR 1 trials but the discriminative stimuli represent a smaller proportion of the total duration of the FR 20 trial than the FR 1 trial (bottom). Thus, the discriminative stimuli should be more predictive of reinforcement on FR 20 trials.

to reinforcement should become a conditioned appetitive reinforcer. Although in the designs described here, the absolute delay to reinforcement was always the same for the two S+ stimuli (see Fig. 2, top), relative to the total trial duration, one of those S+ stimuli could be thought of as a better predictor of food than the other (Fantino & Abarca, 1985). Specifically, the time needed to complete the pecking requirement increased the duration of high ratio trials more than it increased the duration of low ratio trials. If each trial is considered as a whole, then stimuli that followed the FR 20 requirement would occur relatively closer to reinforcement than the stimuli that followed the FR 1 requirement and thus, the stimuli that followed the FR 20 requirement would become better conditioned reinforcers (see Figure 2, bottom) because they would represent a greater reduction in the delay to reinforcement.

Clearly, the delay reduction hypothesis can also account for the effect found when a delay occurs prior to the presentation of the discriminative stimuli (DiGian et al., 2004) because trials with a delay are longer than

trials without a delay. Thus, the onset of the discriminative stimuli would occur relatively closer to reinforcement than on trials without a delay.

Upon initial consideration, it is not clear how the delay reduction hypothesis can account for the manipulation of food and the absence of food prior to the discriminative stimuli (Friedrich et al., 2005). In this case, trial duration should be the same for all trials. But according to the delay reduction hypothesis it is the time between reinforcements that is critical (Fantino, Preston, & Dunn, 1993). Under most discrete-trial procedures, trial duration and interreinforcement time are highly correlated because an intertrial interval of constant duration separates the trials. In the case of food versus the absence of food as a prior event, however, the interreinforcement interval would be much shorter on trials with a food event (there would typically be two food presentations per trial; one as the event that preceded the discriminative stimuli and one as the reinforcement following choice of the correct discriminative stimulus). If those intervals are shorter, the predictive value of the discriminative stimuli should be reduced (relative to their predictive value on trials without food as the prior event) and such discriminative stimuli should not be preferred.

The purpose of the current experiments was to provide a direct test of the delay reduction and contrast hypotheses. In the experiments already described, reinforcement was held constant but trial duration (or interreinforcement interval) was not. In the current experiments, trial duration was equated to provide a more direct test of the delay reduction hypothesis.

EXPERIMENT 1

Previous experiments that investigated the within-trial contrast effect have used one clearly preferred event and one less preferred event (e.g., food vs. the absence of food). In Experiment 1, two different schedules of reinforcement, a differential-reinforcement-of-other-behavior (DRO) and a modified fixed-interval (FI) schedule of reinforcement were used, but with total trial duration equated. On DRO trials, if the pigeon withheld pecking for 20 s, reinforcement was provided.

On modified FI trials, to equate trial duration, the time it took to complete each DRO trial determined the interval on the following FI trial. Although it is not obvious which schedule of reinforcement would be preferred, both schedules result in the same number of reinforcements with the same distribution of trial durations.

According to the delay reduction hypothesis, the pigeons should be indifferent between the two schedules because the relative reduction in the delay to reinforcement should control preference and the reduction in delay to reinforcement associated with the two schedules should be the same (Fantino, 1969). Alternatively, according to the law of least effort, the pigeons might prefer the DRO schedule. However, the DRO schedule is similar to an omission schedule, a variation of autoshaping for which the absence of responding has been relatively difficult to maintain (see Williams & Williams, 1969). In a typical omission-training experiment, reinforcement is provided when an animal refrains from responding to a stimulus that is presented for a particular duration. Responses usually result in delaying access to the reinforcer until the peck-free duration is satisfied. The purpose of Experiment 1 was to determine whether pigeons would demonstrate a preference for the FI or DRO schedule when trial duration was held constant. The contrast hypothesis makes no prediction about which schedule should be preferred, but if there is a preference, then it makes clear predictions about the value of the reinforcer (or the conditioned reinforcer) that follows it (a question that will be addressed in Experiment 2).

METHOD

Subjects

The subjects were 8 White Carneau pigeons (*Columba livia*) that were retired breeders (5–8 years of age) purchased from the Palmetto Pigeon Plant (Sumter, SC). The pigeons were individually housed in wire cages and maintained at 85% of their free-feeding body weights for the duration of the experiment. The pigeons had free access to water and grit in their home cages. The pigeon colony room was maintained on a 12:12-hr light-dark cycle. The pigeons were cared for in accordance with University of Kentucky animal care guidelines.

All pigeons had previous experience in unrelated studies involving a two-sample, two-alternative conditional discrimination.

Apparatus

The experiment was conducted in a standard operant chamber (BRS/LVE, Laurel, MD). The operant chamber measured 32.0 cm high, 32.0 cm across the response panel, and 28.0 cm from the response panel to the back wall. Three square response keys (2.5 × 2.5 cm) were aligned horizontally on the response panel and were separated by 0.8 cm. All response keys were 24.1 cm from the floor of the operant chamber. A 12-stimulus in-line projector (Industrial Electronics Engineering, Van Nuys, CA) with 28 V, 0.1 A lamps (GE 1820) was mounted behind each response key. The two side keys projected a white (unfiltered) stimulus. The center key projected three white parallel lines against a black background arranged either horizontally (H) or vertically (V). The three lines were 2 mm apart and each was 2 mm wide and 2.5 cm long. An unfiltered houselight (GE 1820) mounted in the center of the ceiling illuminated the intertrial intervals (ITI). A rear-mounted feeder provided mixed grain reinforcement (Purina Pro Grains) through a 5.1 cm × 5.5 cm aperture centered horizontally on the response panel and vertically midway between the response keys and the floor of the chamber. Reinforcement consisted of 1.5-s access to mixed grain. An exhaust fan was mounted outside the chamber to mask extraneous noise. The experiment was controlled and data collected by a microcomputer located in an adjacent room.

Procedure

Schedule training. The pigeons were trained initially on two schedules of reinforcement. Each schedule was initiated by a different side key that was illuminated by a white light. For half of the pigeons, on half of the trials, the trial started with the lighting of the left side key (white). A single peck to the left key turned it off and turned on vertical lines on the center key which initiated a 20-s differential-reinforcement-of-other-behavior (DRO 20 s) schedule. Pecks to the vertical stimulus reset the 20-s timer. Reinforcement occurred after 20 s had elapsed with no pecks
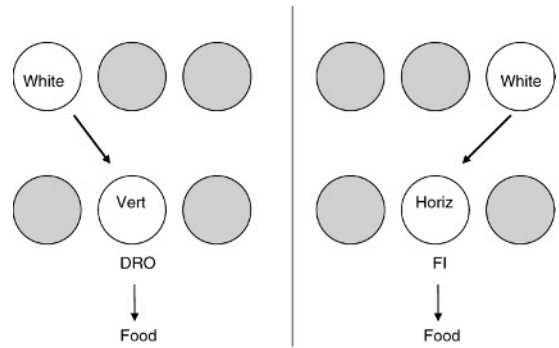

Fig. 3. Schedule training procedure used in Experiment 1. One peck to the lit left key initiated vertical lines on the center key indicating that a DRO schedule was in effect. One peck to the lit right key initiated horizontal lines on the center key indicating that a FI schedule was in effect. The schedule associated with the left and right keys was counterbalanced over subjects.

to the vertical stimulus and was followed by a 10-s lit ITI.

On the remaining trials, the trial started with the lighting of the right side key (white). A single peck to the right key turned it off and turned on horizontal lines on the center key which initiated a modified fixed-interval (FI) schedule. On modified FI trials, the interval on each trial was determined by the duration of the preceding DRO trial. The first peck after that interval had elapsed provided reinforcement and was followed by a 10-s lit ITI. In this way the distribution of trial durations for the two schedules was equated on a trial by trial basis (see Figure 3 for a summary of the design). The schedules initiated on the center key by the left and right lit keys were reversed for the remaining pigeons.

Each session consisted of 72 trials, 36 DRO trials alternating with 36 FI trials. Training sessions were conducted once a day, 6 days a week.

Pigeons remained in schedule training until they were performing with a median trial duration of 20.5 s or less on both FI and DRO trials for two consecutive sessions. After reaching criterion, the pigeons received five sessions of overtraining intended to ensure stability of responding on each schedule.

Schedule preference testing 1. An independent measure of schedule preference was obtained for each pigeon. During the first schedule preference testing phase, sessions consisted of 54 training trials interspersed with 18 test trials

on which the pigeons were given a choice between the left and right white side keys. Whichever white side key the pigeon chose initiated the corresponding schedule.

Pigeons remained in schedule preference testing for a minimum of 10 sessions. If, after 10 sessions, a pigeon had demonstrated a 90% or greater preference for one of the schedules for two consecutive sessions, it was moved to the second testing phase. Otherwise, it remained in the schedule preference testing phase until it had reached a stability criterion of four consecutive sessions in which the range of schedule preference did not vary by more than 20%.

Schedule preference testing 2 (reversal testing). It is possible that if a pigeon chose one side key significantly more often than the other during schedule preference testing, it was demonstrating a side bias rather than a schedule preference. To distinguish between a schedule preference and side key bias, all pigeons were given a reversal test in which the schedules signaled by the side keys were reversed. The horizontal and vertical line stimuli continued to signal the schedule of reinforcement experienced during training and during the first schedule-preference test.

If in the reversal test a pigeon continued to choose the same side key more often that the other key, the pigeon was judged to have a side key bias rather than a schedule preference. If the pigeon reversed its side key preference, it was judged to have a schedule preference.

Pigeons remained in reversal testing until they had achieved a stability criterion of four consecutive sessions in which the range of schedule preference did not vary by more than 20% and a minimum of five sessions. Again, each session consisted of 72 trials (54 training trials and 18 test trials).

RESULTS

One of the 8 pigeons died before reaching the schedule preference training criterion. All of the analyses include only the 7 remaining pigeons. Pigeons reached the initial schedule preference criterion in a range of 7 to 21 sessions ($M = 13.00$, *SEM* $= 2.35$); including overtraining, the total number of sessions of schedule training ranged from 12 to 26 ($M = 18.00$, *SEM* $= 2.35$). The pigeons reached criterion on Schedule Preference Testing Phase 1 in a range of 10 to 16 sessions ($M =$

11.43, *SEM* $= 0.95$). They reached criterion on Schedule Preference Testing Phase 2 in a range of 6 to 15 sessions ($M = 10.14$, *SEM* $= 1.14$).

Overall, there was no consistent schedule preference. Although some of the pigeons did prefer one schedule or the other, others appeared to show a side preference. To determine the pigeons' preference, two preference scores were calculated. First, the schedule preference scores from the last 4 days of schedule preference testing 1 and 2 were combined to obtain an overall schedule preference score. Second, a side preference score was obtained using the mean side preference from the last 4 days of schedule preference testing 1 and 2. For example, if the pigeon chose the schedule associated with the left side during Schedule Preference Testing 1 90% of the time, but chose the schedule associated with the left side during Schedule Preference Testing 2 10% of the time, it would receive a side preference score of 50%, but a schedule preference score of 90%. Whichever overall preference score (schedule or side) was greater defined the pigeon's preference.

Only 3 of the 7 pigeons demonstrated a significant schedule preference, as indicated by a Fisher's exact test. Two of the pigeons preferred the DRO schedule and 1 preferred the FI schedule (see Table 1). The remaining 4 pigeons showed a strong side preference.

DISCUSSION

There was no systematic schedule preference found in Experiment 1. According to the law of least effort there should have been a preference for the DRO schedule, but only 2 of the 7 pigeons demonstrated a significant preference for the DRO schedule. In addition, inconsistent with the law of least effort, 1 pigeon showed a significant preference for the FI schedule. If trial duration is held constant, the delay reduction hypothesis (Fantino, 1969) predicts that no schedule preference should be found. Although there was no systematic schedule preference, each of the 7 pigeons showed a significant preference of some kind (either schedule or side), and 3 of the pigeons showed strong schedule preferences. Experiment 1 does not provide an adequate test of either the delay reduction hypothesis or contrast but it does set the stage for a test of both theories in Experiment 2.

Table 1
Schedule and side preference results from Experiment 1.

Pigeon #	Schedule Preference	Side Preference	Greater Preference
10017	94.44*	61.39	DRO schedule
20835	60.41	72.92*	left side
10050	54.17	88.89*	left side
4335	70.14	74.31*	left side
575	72.23*	69.44	DRO schedule
10015	50.70	96.53*	left side
581	86.80*	60.42	FI schedule

* *preference significantly greater than chance, $p < .05$*

EXPERIMENT 2

Although the contrast account makes no prediction with regard to schedule preference, it does predict that whatever preference the pigeons do have, they should prefer the discriminative stimuli that follow the *less* preferred event. The purpose of Experiment 2 was to test whether preference for discriminative stimuli can be predicted from each pigeons' preference for the immediately preceding event.

METHOD

Subjects and Apparatus

The subjects and apparatus in Experiment 2 were the same as those used in Experiment 1. However, in Experiment 2, in addition to the white (unfiltered) stimulus, the two side keys projected yellow, red, blue, and green hues (Kodak Wratten filters Numbers 9, 26, 38, and 60, respectively).

Procedure

Discrimination training. During discrimination training, each training trial (as described in Experiment 1) was followed by presentation of a pair of discriminative stimuli, with each schedule associated with a different pair of discriminative stimuli. For example, following completion of the DRO schedule, the pigeon was presented with one pair of discriminative stimuli (e.g., red+ yellow−). Reinforcement and a 10-s lit ITI followed the choice of the positive (e.g., red) stimulus. Choice of the S− was followed by the 10-s lit ITI alone. Following completion of the FI schedule, the pigeon was presented with a different pair of discriminative stimuli (e.g., green+ blue−). Choice of the positive discriminative stimulus (e.g., green) resulted in reinforcement and the ITI, whereas choice of the negative discriminative stimulus

resulted in the ITI alone. For 4 of the pigeons, red and yellow stimuli followed the DRO schedule and green and blue stimuli followed the FI schedule (see Figure 4). For the remaining 3 pigeons, red and yellow stimuli followed the FI schedule and green and blue stimuli followed the DRO schedule.

Each session consisted of 84 trials. As in Experiment 1, there were 40 DRO trials alternating with 40 FI trials. The remaining four trials were randomly presented choice trials on which the two white side keys were presented simultaneously and the pigeons were given a choice between the two schedules. Pigeons remained in training until they had reached a criterion of 90% correct for two consecutive sessions.
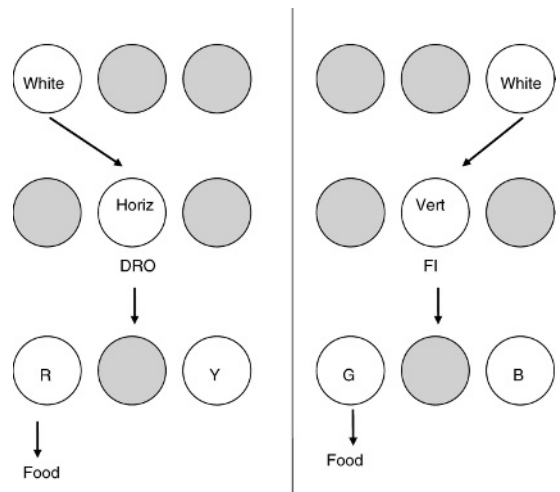

Fig. 4. Design of Experiment 2. The left panel shows a DRO trial with completion of the DRO requirement followed by one simultaneous discrimination (red+ yellow−). The right panel shows a FI trial with completion of the FI requirement followed by a different simultaneous discrimination (green+ blue−). Colors associated with the two simultaneous discriminations were counterbalanced.
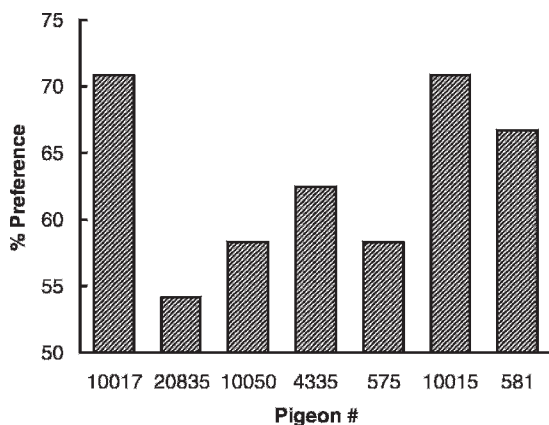
Fig. 5. Experiment 2: Preference of each pigeon for the S+ that followed the less preferred schedule or side on Test Session 4.
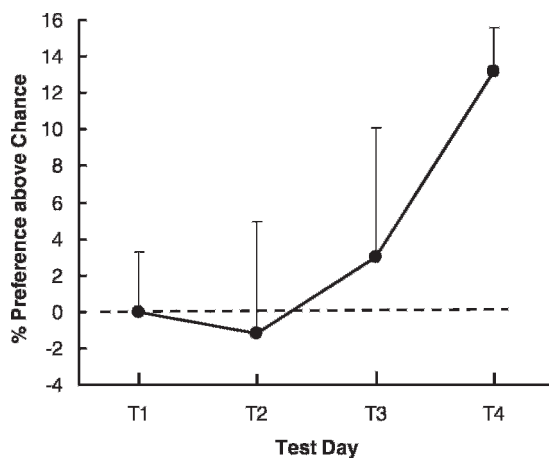

Fig. 6. Mean percentage preference above chance for the S+ that followed the less preferred schedule or side over the four testing sessions in Experiment 2. Error bars represent 1 standard error of the mean.

Discriminative stimulus testing. The testing phase consisted of the trials from the training phase as well as test trials on which the two positive stimuli (e.g., red and green) or two negative stimuli (e.g., yellow and blue) were presented simultaneously. Each novel pair could appear after a DRO schedule, a FI schedule, or could appear immediately after the ITI. On test trials, reinforcement was provided nondifferentially, 50% of the time.

Each test session consisted of 80 trials. There were 32 training trials, as described earlier (16 DRO and 16 FI trials). The remaining 48 trials were test trials. An equal number of test trials (16) began with a FI, DRO, or no schedule. The first test session was administered the day after the pigeon reached the training criterion and served as a baseline test. Although percent correct choices of each S+ provided a measure of the acquisition of the two simultaneous discriminations, we did not have a measure of the relation between the simultaneous discrimination and the schedule that preceded it. For this reason we included 4 test sessions, each separated by 10 additional training sessions.

RESULTS

All 7 pigeons reached criterion on discrimination training quickly (within a range of two to four sessions, $M = 2.86$, $SEM = 0.34$). For the first test session, an overall preference score was obtained by combining the mean preference score from the last 4 days of the reversal testing data from Experiment 1 with the mean preference score from discrimination training in Experiment 2. The number of discrimination training sessions used to determine the overall preference score varied from two to four sessions. For the remaining test sessions, Test Sessions 2 through 4, the preference score was calculated from the mean preference scores from the preceding 10 days of discrimination training.

On Test Sessions 1 and 2, the S+ stimulus preference was negligible ($M = 50.00\%$, $SEM = 3.27$ and $M = 48.81\%$, $SEM = 6.14$, respectively). On Test Session 3, a small, nonsignificant, preference ($M = 52.98\%$, $SEM = 7.08$) was found for the S+ that followed the nonpreferred event in training, $t(6) = .42$, $p > .05$. On Test Session 4, as shown in Figure 5, each pigeon showed a preference for the S+ stimulus associated with the non-preferred schedule or side ($M = 63.17\%$, $SEM = 2.45$). The preference was confirmed statistically by a two-tailed t test, $t(6) = 5.37$, $p < .05$. The increase in preference for stimuli associated with the less preferred prior event over the four testing sessions is presented in Figure 6.

According to the contrast hypothesis, preference for the discriminative stimuli should depend on the degree of avoidance of the preceding event. To test this hypothesis, a Pearson product-moment correlation was performed on the preference scores. The analysis indicated that there was a significant negative correlation between degree of sched-

ule or side preference and preference for the positive stimuli that followed the preferred event ($r = -.78$, $p < .05$). Thus, if a pigeon showed a strong preference for one schedule or side, then on test trials it strongly avoided the S+ stimulus associated with that schedule.

Preference for the negative stimulus associated with the nonpreferred schedule was in the same direction as the positive stimulus and was just as large ($M = 67.26\%$, $SEM = 7.79$, see Figure 7) but because of substantial variability among the pigeons, it was not statistically reliable, $t(6) = 2.22$, $p = .07$. Preference for the S− that in training followed the relatively more aversive event has been explained by Clement et al. (2000) as the transfer of value from the more positive S+ to the simultaneously presented S− (see Fersen, Wynne, Delius, & Staddon, 1991; Zentall, 2004) but reliable S− effects have not always been found (see DiGian et al., 2004; Friedrich et al., 2005), perhaps because the S− effect depends on the S+ for its value.

Finally, on Test Session 4, there also was a positive correlation between average number of pecks made during the FI schedule during the preceding 10 training sessions and preference for the DRO schedule but because of the small number of subjects, the correlation did not reach statistical significance ($r = .49$, $p = .21$). The correlation does suggest, however, that those pigeons that pecked more on the FI schedule also tended to prefer the DRO schedule more.

DISCUSSION

In past research, many of the observed preferences for the discriminative stimuli that follow less preferred events could be accounted for equally well by both the within-trial contrast hypothesis and the delay reduction hypothesis because previous studies typically confounded relative aversiveness with time. In Experiment 2 we tested for contrast under conditions in which the two schedules were equated for duration.

Results from Experiment 2 indicated that the schedule or side-key preference predicted the preference for the stimuli associated with the nonpreferred schedule or side, a result consistent with the contrast hypothesis. Further, the significant negative correlation between schedule/side preference and preference for the S+ associated with that schedule
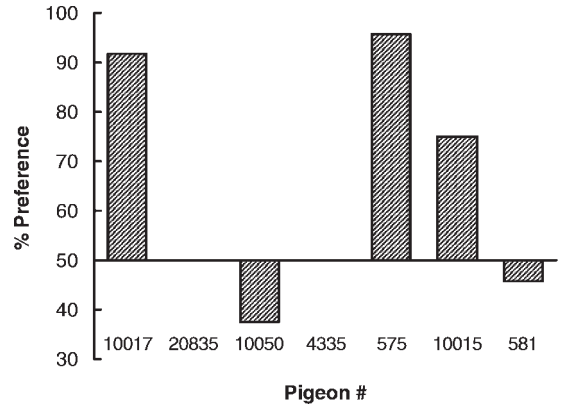

Fig. 7. Experiment 2: Preference of each pigeon for the S− that followed the less preferred schedule or side on Test Session 4.

suggests that the strength of the schedule or side preference provides a good measure of the degree to which the stimuli that follow are not preferred.

Because we had no way to assess the degree to which the relation between the discriminative stimuli and the event that preceded them was developing after an initial baseline test, we tested the pigeons three more times, each time after 10 additional sessions of training. Given the fact that in Experiment 1 the prior event preferences were not as strong as they were in earlier research (e.g., Friedrich & Zentall, 2004) we had no prior basis on which to judge how quickly preferences for the discriminative stimuli would develop.

GENERAL DISCUSSION

In Experiment 1, pigeons developed schedule and side preferences that would serve as the basis for testing predictions made by the delay reduction and contrast hypothesis in Experiment 2. Although the pigeons demonstrated no systematic schedule preference in Experiment 1, in Experiment 2 they demonstrated a significant preference for those discriminative stimuli that followed whichever event they preferred less (schedule or side).

The present results are consistent with previous findings that stimuli that follow less preferred events are preferred over those that follow more preferred events (e.g., DiGian et al., 2004; Friedrich et al., 2005). These results also are consistent with studies in which

stimuli that followed greater ratios of responding were preferred over stimuli that followed lesser ratios of responding (e.g., Clement et al., 2000; Friedrich & Zentall, 2004; Kacelnik & Marsh, 2002). However, the present results cannot be accounted for by the delay reduction hypothesis because the conditions for differential delay reduction had not been met. Thus, contrast provides a better account of the present results and perhaps a more parsimonious account of earlier results as well.

Unlike previous studies in which number of responses was manipulated, in the present study the pecking requirement on the FI trials was rather modest. It is possible that if the total number of pecks on pecking-required trials was greater, a stronger schedule preference would have been observed. This hypothesis is partly supported by the fact that in Experiment 2 there was a moderately strong correlation between pecking on the FI schedule and DRO preference. Future studies should investigate the contrast effect with an increased pecking requirement by replacing the FI schedule with an FR schedule.

It is interesting to note that had the results of the present study and earlier within-trial contrast experiments been found with humans (and they have: see Klein, Bhatt, & Zentall, 2005) they likely would have been interpreted as evidence of a variation of cognitive dissonance known as the *justification of effort*. Cognitive dissonance has been defined as the inner conflict that results when one's beliefs do not match one's behavior (Festinger, 1957) and can be thought of as an attempt to maintain consistency (undoubtedly reinforced by others). In the justification of effort experiment, greater value is placed on an outcome that requires greater effort to obtain (or is more aversive) than on a similar outcome that requires lesser effort to obtain presumably to justify the added effort expended. For example, Aronson and Mills (1959) demonstrated that individuals value group membership more if they have to undergo a severe initiation to join the group, and Aronson and Carlsmith (1963) showed that children valued a forbidden toy more when they were threatened with severe punishment if they played with it. Similarly, students typically value an *A* grade they receive in a difficult course (e.g., organic chemistry) more than the same grade in a presumably

easy course (e.g., physical education), although both grades might have a similar effect on their grade point average. The contrast account described in the present study provides a more parsimonious explanation for behavior that has more commonly been explained in such cognitive terms as 'justification of effort' or 'cognitive dissonance'. It would be of some value if social psychologists were to consider the possibility that contrast effects such as those reported here might account for the results of their experiments as well.

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